

A Unified Equation for Solar Protection

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Abstract

This paper introduces a generalized field-aware model for estimating skin protection duration from solar radiation, taking into account SPF rating, UV index, geospatial position, time of day, skin tone, and day of the year. It integrates solar zenith angle modeling and planetary seasonal harmonics within a simple but powerful equation applicable across multiple latitudes and solar phases.

1 The Unified SPF Protection Equation

We define solar protection duration P in minutes as:

$$P = \frac{S \cdot F}{U \cdot T \cdot \cos(\theta) \cdot \delta} \quad (1)$$

Where:

- P = Protection duration (in minutes)
- S = Skin tone factor (e.g., 1.0 for fair, 1.2–2.0 for darker tones)
- F = SPF rating of the applied sunscreen
- U = UV index at location and time
- T = Time-of-day intensity factor, modeled as:

$$T = 1 + \sin^2 \left(\frac{\pi}{12} (H - 12) \right) \quad (2)$$

where H is the local hour (24h format), peaking at noon.

- θ = Solar zenith angle based on latitude ϕ and day-of-year declination δ_s :

$$\cos(\theta) = \sin(\phi) \cdot \sin(\delta_s) + \cos(\phi) \cdot \cos(\delta_s) \cdot \cos(h) \quad (3)$$

where h is the solar hour angle.

- δ = Seasonal exposure correction based on Day of Year (DOY):

$$\delta = 1 + 0.033 \cdot \cos \left(\frac{2\pi(\text{DOY} - 3)}{365} \right) \quad (4)$$

2 Use and Implications

This equation provides a solar-aware protection metric grounded in field geometry and temporal harmonics. It can be extended to model skin damage thresholds, planetary UV shielding zones, and the tuning of SPF products for extraterrestrial environments.

Future Work

Integration with QRFT-based field strain thresholds may allow this SPF model to become dynamically adaptive for coherence-based shielding technologies and tunable UV filtering resonators.

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